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<p>(54) Title: METHOD AND DEVICE FOR ASSOCIATION OF ANONYMOUS REFLECTORS TO DETECTED ANGLE POSITIONS</p> <p>(57) Abstract</p> <p>A method for association of anonymous reflectors (R<sub>1</sub>-R<sub>11</sub>) to detected angle positions, whereby a) the anonymous reflectors are arranged in positions in a transport area; b) positions of the reflectors (R<sub>1</sub>-R<sub>11</sub>) are stored in first memory means (20); c) a beam (B) is emitted from an emission source (13) of a vehicle (10) over a search sector; d) reflected signals from reflecting objects are received on board the vehicle (10); e) an angle position towards reflecting objects in relation to a reference direction (D) of the vehicle (10) is continuously detected by detector means (18) during the sweep of the beam over the search sector, and corresponding angle values are determined; f) at least one angle value determined over the search sector is stored in a second memory means (21). The distances between reflectors (R<sub>1</sub>-R<sub>11</sub>) and a reference point on the vehicle (10) is determined continuously by a control means (19). A relation between the distance values and the corresponding distances between stored reflector positions and a position assumed for the vehicle is determined by control means (19), the association being allowed if the relation is within an expected interval.</p>			

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Method and device for association of anonymous reflectors to detected angle positions.

## SCOPE OF THE INVENTION

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The invention relates to a method and device for control of an automated guided vehicle according to the preamble of Claims 1 and 9.

## STATE OF THE TECHNOLOGY

10 Automated guided vehicles are used in many industrial settings, for example in the form of trucks for transport of goods in factories and warehouses. According to a commonly used system, magnetic loops or similar are laid out along the transport paths of the trucks. As a result of high initial costs and difficulties in later modification of the route followed by the 15 trucks, systems with locational light reflectors have been developed.

According to certain known systems, reflectors are used with identification, i.e., on the basis of the reflected signal instruments on the vehicles can directly determine which unique reflector the signal is coming from. Such systems can be fast and effective, but the unique reflectors are 20 relatively expensive. There are also limitations as regards the distance at which the signal can be registered and similar problems.

A navigation system with completely anonymous reflectors in the form of reflector strips or similar is illustrated and described in US-A-4811228. The reflectors lack identity, but they are exactly calibrated as to their position. The 25 position of each reflector is stored on board the vehicle together with relevant coordinates for the transport area. A light source on board the vehicle sends out a concentrated laser beam that sweeps over the transport area. Reflections from the reflectors and other objects are registered and give bearings to a possible reflector.

30 The following measures are taken initially with stationary vehicles for association of the bearing or angle positions to physical reflectors when the vehicle is located in a known position. Three angle values are chosen with suitable distribution over the area to be searched across. The angle values are associated with reflectors and the position of the vehicle is determined

on the basis of the known position of the detected reflectors. If the position of the vehicle determined in this way is in agreement with the known position, the remaining angle values are associated. These measures are repeated for every possible combination of three angle values, and a combination of associations with good agreement on the position of the vehicle is chosen.

5 The following measures are continually taken for association of the angle positions to physical reflectors. A detected angle position is compared with possible angle positions of stored positions for reflectors, and this angle position is associated with a physical reflector, which yields good agreement with the stored position of a reflector.

10 After the angle positions or bearings to the reflectors have been associated to actual reflectors, the determination of position and navigation can occur in various ways. Initially triangulation is used. With certain knowledge of the expected position at a point of measurement other

15 methods are used during further travel. The automated guided vehicle is also provided with equipment for continuous updating of the vehicle's motion, for example, through an odometer. In the first place, it is the route traveled by the vehicle between measurement points that is continuously determined, but also the movement of the vehicle while making turns and its direction of movement is determined. Measurement can occur, for example, with respect to the rotation of the drive wheels or other wheels, such rotation then being converted to distance. Also the angle of turn of the vehicle's steering wheel is preferably determined continuously. Data regarding the distance and direction are used as a basis for determination of position and navigation.

20 25 In order for the system described in US-A-4811228 to achieve the best performance, a large number of reflectors is required. Since calculation of many combinations is required before a certain association can be made, the time needed for calculation is long. This disadvantage can be only worse if many detected signals originate from sources other than the anonymous

30 reflectors known by their positions, for example from metal objects or windows.

It would therefore be desirable that improved possibilities to filter out undesirable reflections, to increase effectiveness of association, and to lessen the number of required reflectors be present in a system of the type described in US-A-4811228.

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### THE INVENTION IN SUMMARY

A purpose of the invention is to produce a method and device for control of automated guided vehicles, whereby the disadvantages cited above are avoided at the same time as the desired improvements are achieved. These aims are achieved by the integration into the invention of the special features described in Patent Claims 1 and 12.

According to the invention the current distance to the object from where the signal has been reflected is determined in connection with the receiving of a reflected signal on board the vehicle. The distance is compared with the corresponding distance between a reference point on the vehicle in an assumed position and the stored position of a possible reflector. Information concerning the distance is used to make possible more certain judgment of the identity of the reflector.

Further certainty can be achieved if more complete information about the reflectors is collected ahead of time and is available for judgment of the identity of the reflectors. For example, it can be determined ahead of time how the intensity of a signal reflected from reflectors varies with the angle of incidence and distance to the reference point on the vehicle. The sweep time across the reflector can also be determined. This can be true of different types of reflectors, both with respect to the form of the reflectors and the material from which they are manufactured. Another advantage that can be achieved according to the invention is that the determination of the position can occur faster and with greater certainty, even initially, with no knowledge of the current position.

Further advantages and special features of the invention can be seen from the following description, drawings, and dependent patent claims.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described in more detail with the aid of examples of embodiments with reference to the attached drawings on which:

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FIG 1 is a schematic perspective view of an automated guided vehicle exploiting use of the invention,

FIG 2 is a schematic plane view from above of part of the work area of an automated guided vehicle which is provided with an instrument according to an embodiment of the invention,

10 FIG 3 shows schematically how a signal can be configured to make possible a measurement for distance,

FIG 4 shows schematically how the amplitude in a reflected signal varies with the angle of incidence of incoming light,

15 FIG 5 shows schematically how the amplitude in a reflected signal varies with the distance between the light source/detector and reflecting objects,

FIG 6 shows schematically how the duration of a reflected signal varies with the distance between the light source/detector and reflecting

20 objects at perpendicular incidence and

FIG 7 is an enlargement of the plane view in FIG 2.

## THE INVENTION

25 Vehicle 10 shown in FIG 1 is embodied as a truck. At the top of a drive and control unit 14 there is provided an emission source 13. The emission source emits a beam B that preferably sweeps around on a plane in the transport area which the vehicle will move about in. The beam can be of various types and, for example, is constituted of light, another electromagnetic beam, or

30 another beam. It is also possible to let the beam illuminate various portions of the transport area discretely point by point or by sectors during various time intervals. In a preferred embodiment the emission source is a light source and the emitted beam is a concentrated laser beam.

In the embodiment shown the vehicle is equipped with means for control with the aid of odometry. Among these means are wheels 15, of which one or more are driving wheels connected with drive unit 14, and one or more are steering wheels with which the vehicle is steered on the desired track. For this purpose one or more of the wheels is provided with instruments for measurement of the rotation of the wheel by which the distance traveled by the vehicle can continuously be determined. The angle of the steering wheel or of the steering wheels is continuously determined by instruments to measure the angle so that the orientation of the vehicle and its travelling direction can continuously be determined. Drive unit 14 and the wheels can be embodied in another way in the embodiment that lacks control by means of odometry. Corresponding control characteristics can be brought about with, for example, gyroscopes, accelerators, and similar devices.

On board vehicle 10 there is provided an emission source 13 with controller 19. Emission source 13 preferably contains a laser or another device with the ability to emit a concentrated laser beam B. Beam B can be made to rotate around in a search area which can encompass a closed circle. The rotating function can be brought about by letting light beam B be guided through rotating optical instruments such as mirrors and prisms or by letting the light source rotate. On board the vehicle there are also provided receivers that include a detector means 18, which is a light-sensitive and direction-dependent instrument. The position of detector 18 preferably constitutes the vehicle's reference point. An angle sensor continuously emits an angle signal that indicates the direction of light beam B in relation to a reference direction D on the vehicle. There are provided memory means 20 which store data regarding the transport area and reflectors. Detector 18, controller 19, and memory 20 are operatively connected with each other. Preferably, memory 20 is provided together with detector 18 and controller 19 on board vehicle 10.

According to the invention reflectors are placed at well-defined positions in the transport area. In the embodiment according to FIG 2 a

number of reflectors  $R_1-R_{11}$  are placed in part of the transport area of a warehouse or similar bordered by walls 11. An automated guided vehicle 10 moves through the transport area along a predetermined route 12. Route 12 can easily be altered, for example when remodeling the warehouse, by

5 changing appropriate data in a memory, which is preferably a semiconductor memory or magnetic memory.

Reflectors  $R_1-R_{11}$  are identical in the embodiment shown. Their position is exactly determined beforehand and stored in a memory together with other relevant information on the transport area and the route vehicle 10 is intended to follow. Some form of CAD system is suitably employed for description and definition of the transport area and position of the reflectors. Also in other embodiments it is possible to embody reflectors  $R_1-R_{11}$  so that they cannot directly be identified by the signal which is reflected from them or be associated to corresponding reflectors stored in the memory. According to

10 a preferred embodiment the reflectors are comprised of plane disks or bands of retro-reflecting reflective material. The reflectors preferably have less extension horizontally than vertically in order to have sharp lateral limits. For obtaining a secure reflection from a reflector the angle of incidence for beam B should be less than  $\beta$  from the normal direction N.

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20 According to another embodiment cylindrical retro-reflectors are used. This type of reflectors is positioned preferably so that the axis of the cylinder is perpendicular to the plane that the beam moves in. Beam B will thus be given a good reflection around the entire periphery along the horizontal plane.

25 In other embodiments suitable available objects are used as reflectors. The arrangement of reflectors in such embodiments means that suitable objects must be selected and that the position of the objects must be determined exactly.

30 Light beam B sweeps around with angular velocity  $\omega$  and is reflected from reflectors  $R_1-R_{11}$  and other objects O, for example, tubes, windows 17, or objects on support members 16. A reflected signal is received on board the vehicle by receiver means, which include a light-sensitive detector. The

light-sensitive detector also registers the intensity of the received signal in connection with the angle sensor in such a way that the latter registers at which angle a reflecting object is located in relation to reference direction D. In a preferred embodiment the current angle is registered when the reflected signal begins to be received, but other sequencing is possible. Signals corresponding to a value of the current angle and an incoming intensity value for a certain number of reflection signals are stored in memory, for example, on board the vehicle.

The principle for navigation of automated guided vehicle 10 in the embodiment according to FIG 2 is that an initial determination of the position is made with aid of three angle values associated with reflectors. With a stationary vehicle and a bearing to three reflectors the vehicle's position can be determined exactly, for example, by triangulation. The sequence which can be used consists of the following: three angle values with suitable distribution over the sector being swept are selected; the angle values are associated with possible reflectors, and a possible position of the vehicle is determined on the basis of the known position of the assumed reflectors; if the position determined for the vehicle in this way is within some part of the transport area, remaining angle values are associated with stored reflector positions. The number of angle values that cannot be associated, i.e., which deviate too much from expected angle values for stored reflector positions, is determined. If the number of deviating angle values is greater than a certain value, the position determined for the vehicle is rejected. A status value or quality factor is stored in memory for the angle values which lie within a certain angle interval around the expected angle values. This is repeated for every possible combination of three angle values, and a combination of associations with the best agreement on the position of the vehicle is selected. The position that has the lowest mean deviation for the remaining angle values is preferably selected.

When the vehicle is further displaced along track 12, the determination of position and navigation is done in a different way, mainly because the position of the vehicle is essentially known. For every point of

position determination the latest recorded angle values that give a bearing towards a reflector are used. In position  $P_n$ , in FIG 2, a bearing or angle value to reflector  $R_3$  is used. In doing this, information concerning the position is given only with respect to a line. The information is compared with

5 the position determined by dead reckoning and is corrected with respect to the direction exactly determined to reflector  $R_3$ . In position  $P_{n+1}$ , reflector  $R_6$  is used for determination of the position, and since reflector  $R_6$  is displaced in its angle in relation to the earlier indicated reflector  $R_3$ , the new information concerning the direction will sharply increase the certainty of the

10 determination of position and correction of the position determined by dead reckoning or odometry. A corresponding new determination is made in position  $P_{n+2}$  with reflector  $R_8$  as the basis. A new reflector is preferably selected for every point of determination, so that the certainty of position determination is as high as possible.

15 In the current transport area there are also a number of objects  $O$ , which reflect light emitted from the vehicle and/or emit light which can be detected as a possible reflector by the receiver on board the vehicle. Information on objects of this kind and elements are stored preferably together with information on the position of the reflectors and can be used for

20 navigation. Information regarding other elements disturbing and hindering navigation in the transport area like walls 11, supports 16, and similar objects that can conceal a reflector can also be stored.

The distance to the reflecting object is also determined in connection with a reflected signal detected by the receiver on board the vehicle.

25 Different procedures can be used. In an embodiment according to the invention the emitted light signal is modulated, for example, in the way indicated in FIG 3. The time period  $T$  is in this case 500ns (2MHz). The phase displacement which occurs between the emitted signal I and received signal II corresponds to time  $\Delta t$  and can directly be converted as (double the)

30 distance to the reflector. The selected time period  $T$  makes possible a measurement of distance up to 75 m. In addition, the duration of time until

the reflected signal is detected is determined. The duration is a measure of the size of the reflected object as seen from the vehicle.

The distance can also be measured in other ways and with other instruments than those used with the determination of direction. It is, for 5 example, possible to use another electromagnetic beam or ultrasound for distance measurement.

Information regarding reflective characteristics at different angles and 10 how the intensity of reflected light varies with the distance between the reflector and detector is stored along with information on the position of each reflector.

FIG 4 shows schematically how the reflective characteristics of the reflector can vary with different angles of incidence in relation to the normal direction N of the reflector, when a plane reflection is used. At 0 degrees maximum reflection occurs and at  $\pm\beta$  the reflective ability sinks to a lower 15 threshold value. On the X-axis the angle of incidence is shown in degrees, and on the Y-axis the amplitude is shown. FIG 5 shows schematically how the intensity of the reflected light decreases with the distance between the reflector and detector. On the X-axis the distance is shown, and on the Y-axis the amplitude is shown. FIG 6 shows schematically how the duration of 20 the reflected light decreases with the distance between the reflector and detector. The relations made clear in FIG 4, FIG 5, and FIG 6 are stored as reference values in memory, for example, in the form of tables or calculation steps, so that the relations can be used in judgment of whether a signal 25 coming to the detector actually originates from a reflector. Information on other reflecting objects like, for example, shiny pipes and windows, can be stored in a similar way. Preferably information on reference values is stored during an initial phase and not in conjunction with association or navigation.

When plane reflectors are used, the time during which a reflected signal returns is compared with corresponding reference values and gives a 30 measure of the reflected object's angle of rotation in relation to the reference point on the vehicle.

The judgment of whether an incoming signal actually originates from a reflector, and in that case from which reflector it can be a question of, occurs in several steps. In a first step, signals are rejected that originate from objects which are located farther away from the vehicle than a

5 predetermined but alterable farthest distance. Similar filtering can occur regarding objects that are located too close to the vehicle.

The duration of the received signal is also determined, whereby the duration beyond a certain interval leads to the signal's not being considered during following steps and will not lead to association with a reflector. The

10 interval has limits that are given initial values but which after that can be adjusted to current conditions. The duration corresponds to the angle that the detector or corresponding optical instrument has time to rotate while the reflected signal is received. This corresponds in turn to the part of the reflecting object in the plane of rotation visible from the detector. An overlong

15 signal can in this respect be the result, for example, of reflection from a wall located nearby with a strongly reflecting outer surface.

In a similar way signals with an intensity value outside of a certain interval are rejected. The interval has limits that are given initial values but which can then be adjusted to current conditions.

20 A set of reference values for reflectors used with respect to the duration and intensity of the reflected signal, as dependent on different distances between the reflector and the detector, can be stored ahead of time. The reference values are used to compensate for measured duration and intensity values with respect to the distance, so that the selection of

25 reflection signals used is favorable.

The reflections, which fulfill the conditions named above, are considered in the following as possible reflector signals for subsequent navigation that will be associated with the reflectors stored in memory. These reflector signals are preferably given status values, depending on how well

30 they agree with a nominal reflection signal, or signature, from a known reflector.

The position of the known reflectors is found stored in memory as given above. The connection between a reflection and a real reflector is made with an assumed position of the vehicle as the starting point. Normally the assumed or expected position during travel is determined by odometry,

5 but also other methods can be used. Under the assumption that a reflected signal originates from a certain reflector, consideration is given to the following factors:

\* if the measured distance lies within a predetermined interval from the distance between the position of the vehicle and the reflector;

10 \* if the amplitude or intensity of the received signal lies within a predetermined second interval from the expected amplitude with respect to the amplitude decreasing with distance, for example, according to the diagram in FIG 5;

\* if the duration of the received signal lies within a third predetermined interval from the expected duration with respect to the distance of the reflector to the vehicle;

\* if the measured bearing lies within a predetermined fourth interval from the expected bearing in relation to the reference direction of the vehicle;

\* if the intensity of the received signal lies within a predetermined fifth

20 interval from the expected intensity with respect to the angular position of an expected planar reflecting object, whereby the angle position is determined by the relation between a determined duration and a duration expected at the current distance.

The factors are weighed together and result in a value that corresponds to a probability that an agreement exists. The factors can be judged in a different sequence than that given above. Similarly, different weight can be put on the different factors. The bearing has preferably a great importance with association of a reflected signal with a known reflector. Associations are made continuously during operation, and normally several 30 associations can be made between two determinations of position following each other. A late association, or preferably the association made most

recently, is used with approved agreement continuously in the determination of position.

A computer, preferably on board vehicle 10, has access to information that was collected and stored with reference to the special geometry of the vehicle's steering. Based on information on distance, steering angle, and a model of the vehicle's travel, the displacement of the vehicle is calculated at certain time intervals. Updating of the position is accomplished with the aid of a Kalman-filter. The bearing from this calculated position to the reflector selected is compared with the current measured angle value. The difference between the bearing and the angle value is used for correction of the position in the direction that the angle measurement allows.

The determination of position with the aid of angle calculation allows for a greater degree of precision than odometry. Uncertainty of the position can be seen as an ellipse on the x/y plane that grows if only odometry is used and which "flattens out" in the direction transverse to the reflector when determining the position with the aid of the reflector angle. From this it follows that it is suitable to use reflector angles that distribute themselves approximately evenly all around. Monitoring of the uncertainty of the position occurs continuously. If the uncertainty becomes too great, the vehicle is brought to a stop.

When vehicle 10 is located in position  $P_{n+1}$  in FIG 7 a number of reflections will impinge on the detector during the sweep of beam B during a measurement period. In FIG 7 the reflections from actual reflectors are marked with dotted lines, while the reflections from other objects are marked with dashed lines. Useful signals come from reflectors  $R_2$ ,  $R_3$ ,  $R_4$ ,  $R_6$ , and  $R_{11}$ , and it is the signal from  $R_6$  that is used, which is marked with a solid line. During the sweep of beam B, signals from objects  $O_1$ ,  $O_2$ ,  $O_3$ ,  $O_5$ , and  $O_6$  are also detected. The signals from object  $O_3$  and the reflector  $R_6$  could be confused, at least in some positions along track 12, but because of distance measurement and other processing of signals the risk of confusion is dramatically lessened. In this position support 16 shields reflector  $R_{10}$ , and it is suitable and advantageous to store information of this type regarding

hindrance to line-of-sight in the memory mentioned. Given the problem of associating a reflection with a reflector, such information can be used to exclude certain reflectors already from the beginning.

5 Signals from reflectors  $R_2$ ,  $R_3$ ,  $R_{10}$ , and  $R_8$  in position  $P_{n+2}$  can be used in a similar way. In addition, disruptive signals come from objects  $O_1$ ,  $O_2$ ,  $O_4$ ,  $O_6$ , and  $O_7$ . Also in this position the risk of confusion between reflectors and other objects can be sharply reduced if consideration is taken of the measured distances and the signature of the reflected signal.

## PATENT CLAIMS

1. A method for association of anonymous reflectors (R<sub>1</sub>-R<sub>11</sub>) to detected angle positions, whereby
  - 5    a) the anonymous reflectors are arranged in positions in a transport area,
  - b) positions of the reflectors (R<sub>1</sub>-R<sub>11</sub>) are stored in memory,
  - c) a beam (B) is emitted from a vehicle (10) over a search sector,
  - d) reflected signals from reflecting objects are received on board the vehicle (10),
  - 10    e) an angle position towards reflecting objects in relation to a reference direction (D) of the vehicle (10) is detected over the search sector and corresponding angle values are determined,
  - f) at least one angle value determined over the search sector is stored,
- 15    *characterized* by determining continuously the distances between reflectors (R<sub>1</sub>-R<sub>11</sub>) and a reference point on the vehicle (10), and determining a relation between the distance values and corresponding distances between stored reflector positions and a position assumed for the vehicle, the association being allowed if the relation is within an expected interval.
- 20    2. A method according to Claim 1, *characterized* in that the duration of the reflected signals are continuously detected during the sweep of the beam over the search sector, and the value of the duration is determined,
- 25    that a relation between the value of the duration and an expected value is determined, and that the association is allowed, if the relation is within an expected interval.
- 30    3. A method according to Claim 1, *characterized* in

- that the expected duration of a reflected signal at different distances between the reflector and the reference point on board the vehicle is established in the form of duration reference values,
- that the duration of the reflected signals are continuously detected during the sweep of a beam moving over the search sector, and the value of the duration is determined,
- 5 that a relation between the duration reference value and measured duration value is determined, and
- that the association is allowed, if the relation is within an expected interval.

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4. A method according to Claim 1, characterized in

- that the expected intensity of a reflected signal at different distances between the reflector and the reference point on board the vehicle is established in the form of intensity reference values,

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- that an intensity value of reflections from reflective objects is determined,
- that the relation is established between the determined intensity value and an expected intensity value of a reflected signal at the measured distance, and

- that the association is allowed, if the relation is within an expected interval.

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5. A method according to Claim 2, characterized in

- that the reflectors ( $R_1-R_{11}$ ) are made plane,
- that the expected intensity of a signal reflected from a reflector ( $R_1-R_{11}$ ) at different distances is established in the form of intensity reference values,

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- that the expected duration of a signal reflected from a reflector ( $R_1-R_{11}$ ) at different distances is established in the form of duration reference values,

- that the expected intensity of a signal reflected from a reflector ( $R_1-R_{11}$ )

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- with respect to the angle position of reflector ( $R_1-R_{11}$ ) in relation to a normal direction is established in the form of an angle factor,

- that an angle position of the reflectors ( $R_1-R_{11}$ ) in relation to the angle of line-of-sight to the vehicle (10) is determined on the basis of the

relation between the detected duration and the duration reference values,

that the expected intensity value from a reflector ( $R_1-R_{11}$ ) at the distance measured from the reference point is adjusted with regard to the 5 intensity reference value and the angle factor, and

that the association is allowed, if the intensity of the reflected signal is within a predetermined interval around the adjusted intensity value.

6. A method according to Claim 5, characterized in

10 that the intensity reference values at different distances are stored as values in a table,

that duration reference values at different distances are stored in a table, and

15 that angle factors at different angles are stored in a table, the table values being used when assessing whether to allow association.

7. A method according to Claim 1, characterized in

that the emitted beam (B) is modulated,

20 that the reflection received from objects in the transport area is compared with the emitted beam with regard to time delay, and

that the distance between the vehicle (10) and the object is determined on the basis of the time delay between a certain phase position of the emitted beam and the corresponding phase position of the received beam.

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8. A method according to Claim 7, characterized in

that the emitted signal is modulated with a square wave with a frequency of approximately 2 MHz.

30 9. A method according to Claim 1, characterized in

that the emitted beam (B) is a laser beam.

10. A method according to Claim 1, characterized in

that the emitted beam (B) is constituted of microwave radiation.

11. A device for association of multiple anonymous reflectors (R<sub>1</sub>-R<sub>11</sub>) present in a transport area, to detected angle positions, comprising:

- 5      a) a vehicle (10) with a drive and steering unit (14),
- b) first memory means (20) for storing the positions of the reflectors (R<sub>1</sub>-R<sub>11</sub>),
- c) an emission source (13) for emitting a beam (B), and control means (19) for moving the beam (B) from the vehicle (10) over a search sector,
- 10     d) detector means (18) for continuous angle position detection of a reflected signal in relation to a reference direction (D) of the vehicle (10) during the sweep of the beam over the search sector, and for determination of the corresponding angle value,
- e) second memory means (21) for storing multiple angle values determined over the search sector,

15

characterized in

that control means (19) is provided to continuously determine the distances between (R<sub>1</sub>-R<sub>11</sub>) and a reference point on board vehicle (10) and to store the corresponding distance values in memory means (20), and

that control means (19) is provided to continuously determine a relation between the distance values and the corresponding distances between stored reflector positions and a position assumed for the vehicle, the association being allowed if the relation is within an expected interval.

12. A device according to Claim 11, characterized in

that control means (19) is provided to continuously detect the duration of reflected signals during the sweep of the beam over the search sector and determine a value of the duration.

13. A device according to Claim 11, characterized in

that control means (19) is provided to continuously detect the intensity of reflected signals during the sweep of the beam over the search sector and determine a value of the intensity.

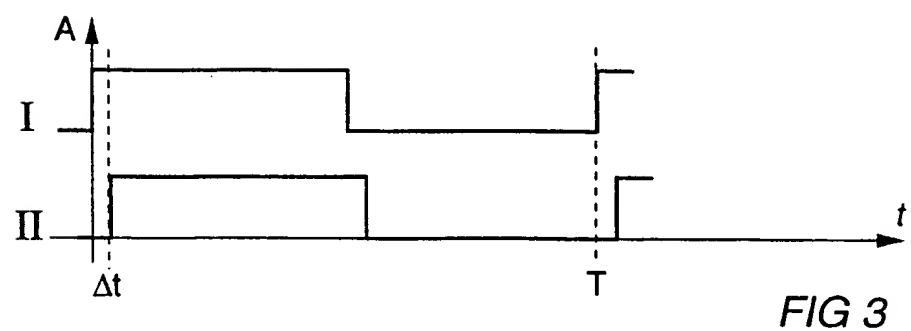
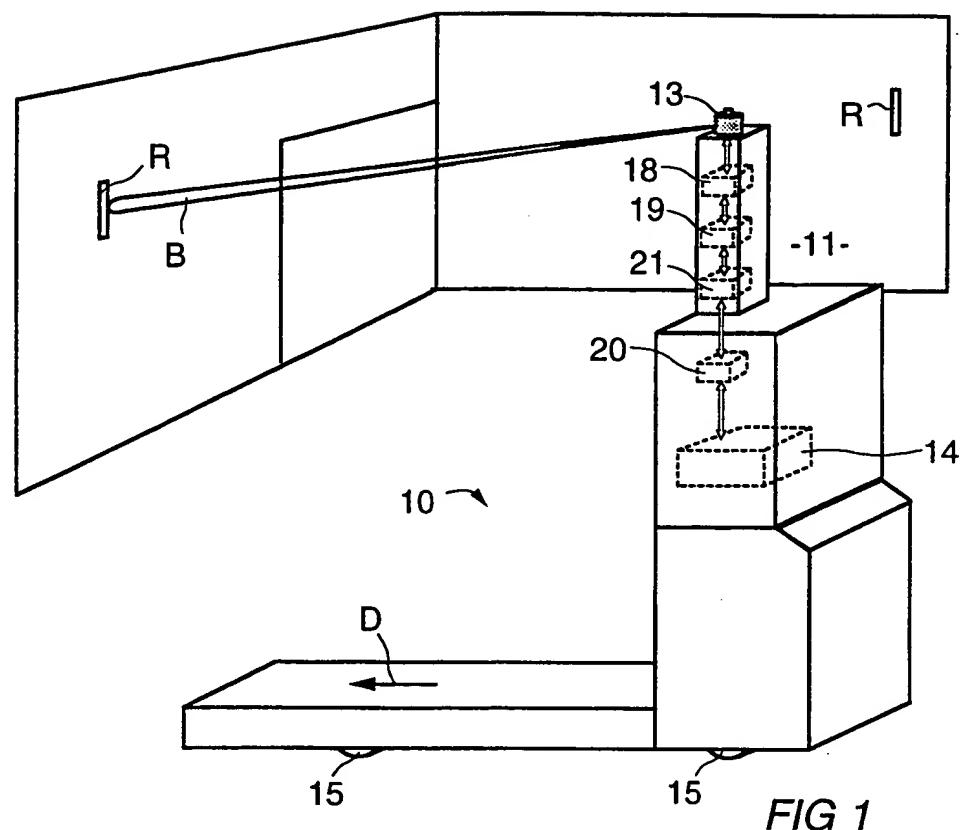
5 14. A device according to Claim 11, characterized in that memory means (20) is provided to store, as duration reference values, the expected duration of a signal reflected at different distances between the reflector and the reference point on board the vehicle.

10 15. A device according to Claim 13, characterized in that memory means (20) is provided to store, as intensity reference values, an expected intensity value of a signal reflected from a reflector ( $R_1-R_{11}$ ) depending on the distance between reflector ( $R_1-R_{11}$ ) and detector means (18).

15 16. A device according to Claims 14 and 15, characterized in that the reflectors ( $R_1-R_{11}$ ) are made plane,  
that control means (19) is provided to continuously determine an angle factor from a relation between the determined value of the duration and a duration reference value, and  
20 that control means (19) is provided to continuously adjust the expected intensity value with regard to the angle factor and the intensity reference value, the association being allowed if the relation between the adjusted intensity value and the determined intensity value is  
25 within an expected interval.

17. A device according to Claim 11, characterized in that drive and steering unit (14) is provided to modulate beam (B), and that drive and steering unit (14) is provided to determine the distance between the vehicle and reflector ( $R_1-R_{11}$ ) depending on the time offset between the phase position of the emitted beam (B) and the corresponding phase position of the received beam.

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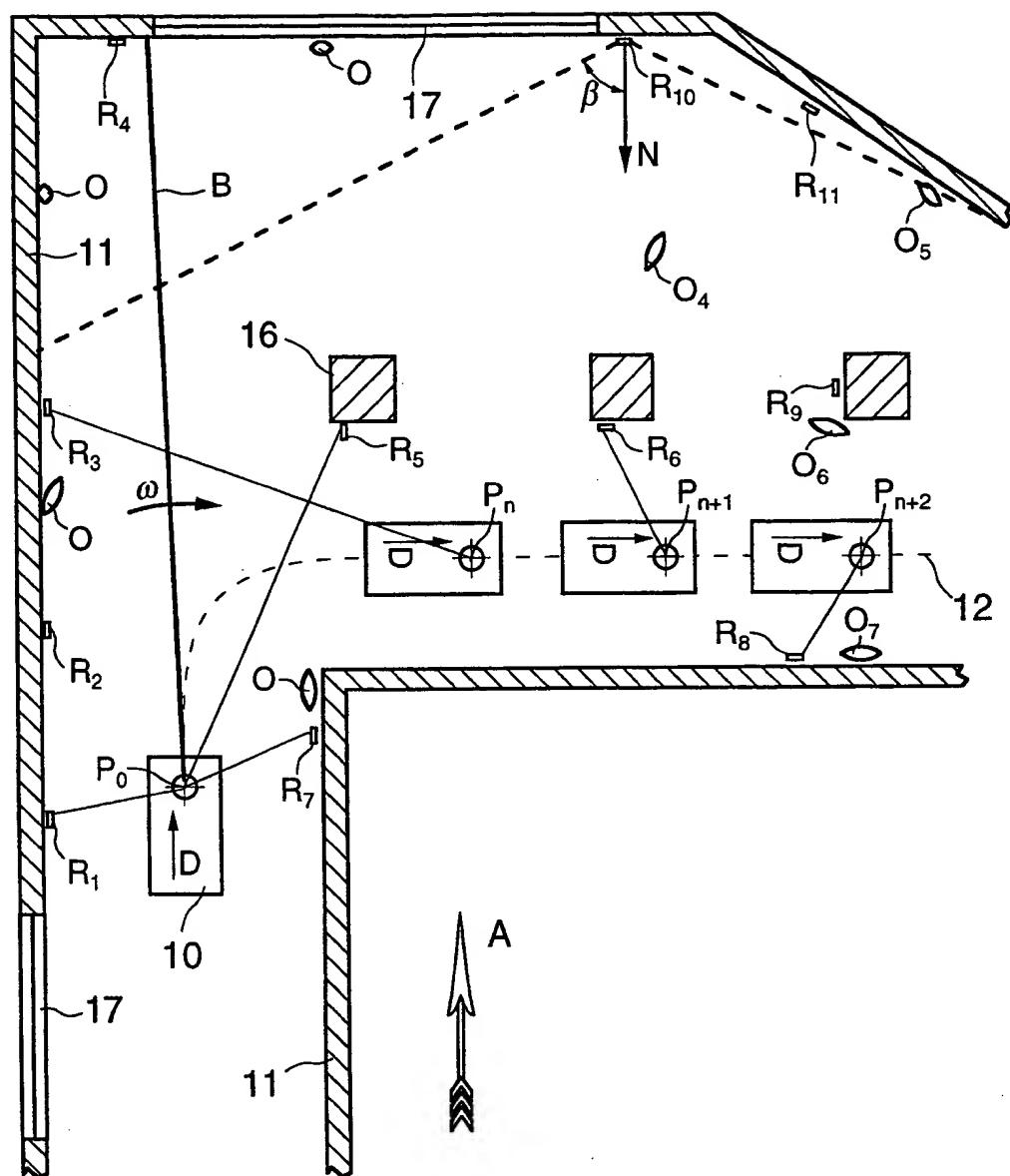


FIG 2

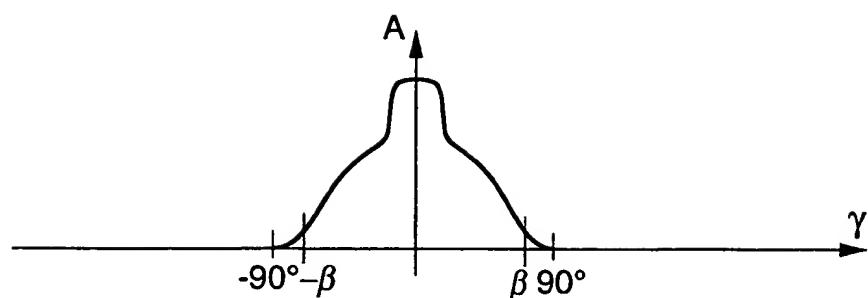


FIG 4

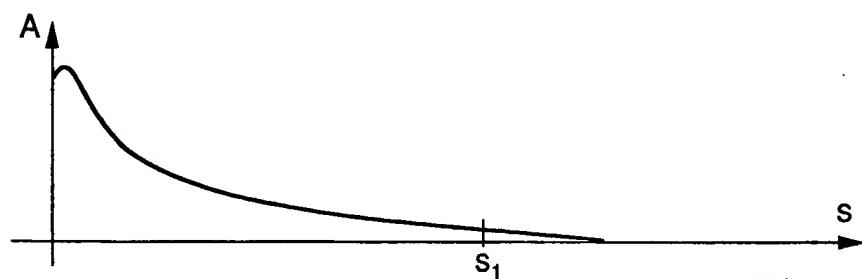


FIG 5

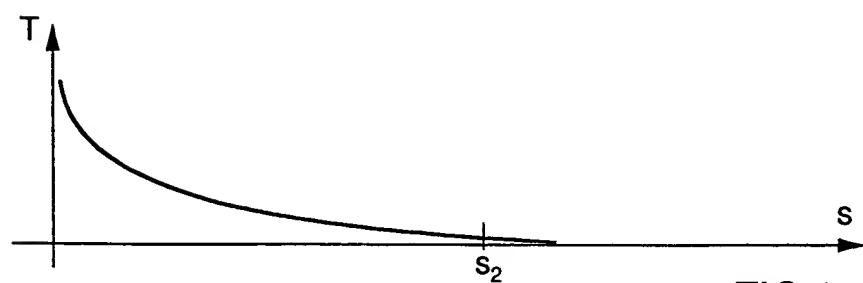


FIG 6

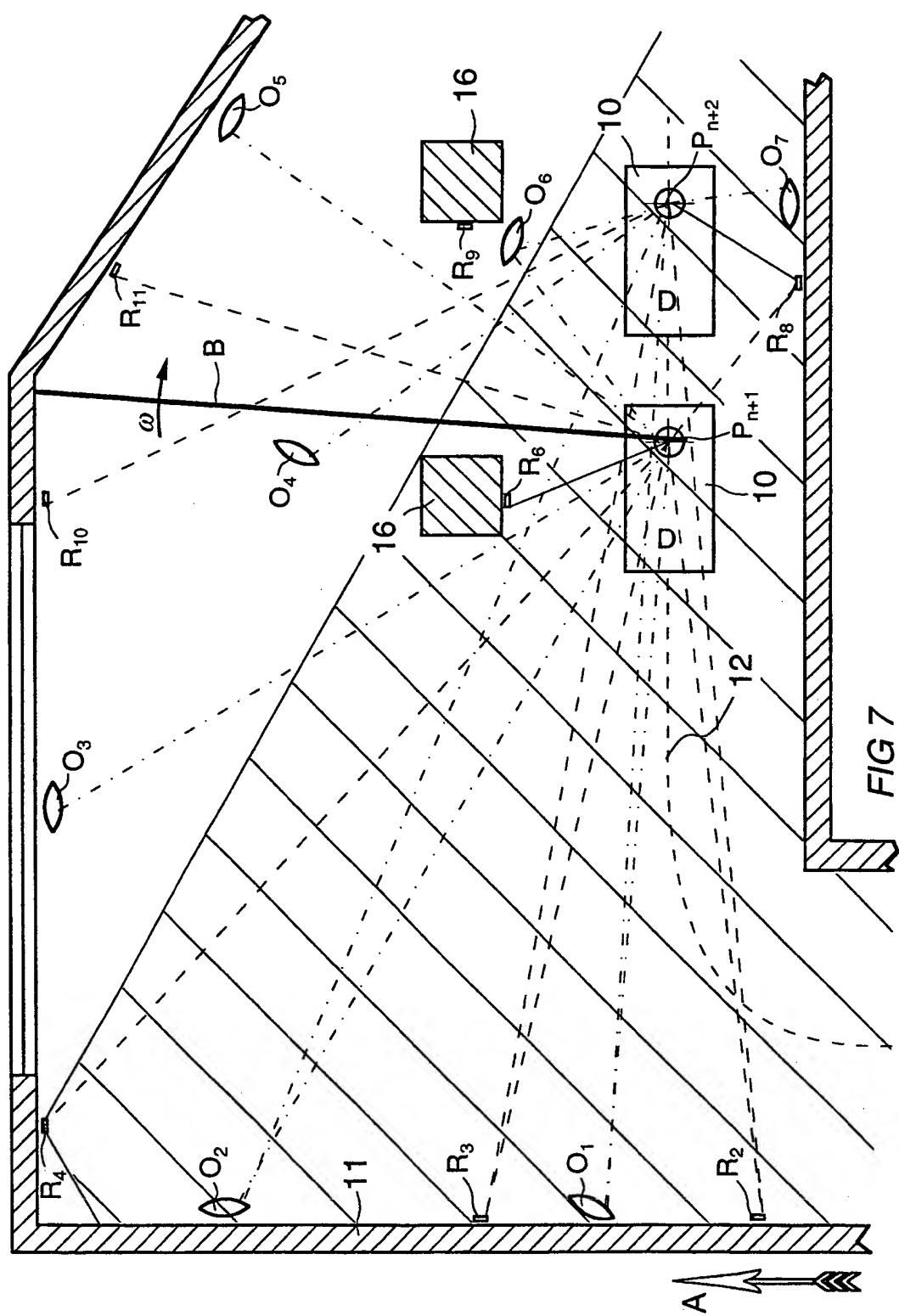


FIG 7

## INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 98/01839

## A. CLASSIFICATION OF SUBJECT MATTER

IPC6: G01S 5/08, G05D 1/03

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: G01S, G05D

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE, DK, FI, NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

WPI

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5367458 A (MALCOLM ROBERTS ET AL), 22 November 1994 (22.11.94), column 8, line 64 - column 10, line 57; column 12, line 45 - column 13, line 28, figures 4,6,9  --	1-3,9-12,14
A	WO 9529380 A1 (SIMAN SENSORS & INTELLIGENT MACHINES LTD.), 2 November 1995 (02.11.95), abstract  --	1-17
A	US 4811228 A (KALEVI HYPPÄ), 7 March 1989 (07.03.89), cited in the application  -----	1-17

 Further documents are listed in the continuation of Box C. See patent family annex.

* Special categories of cited documents:	
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Date of the actual completion of the international search

17 March 1999

Date of mailing of the international search report

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**INTERNATIONAL SEARCH REPORT**  
Information on patent family members

02/03/99

International application No.	
PCT/SE 98/01839	

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